

Appl. No.: 10/716,232
Amdt. dated: March 1, 2006
Reply to Office Action of: November 1, 2005

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (currently amended): A method of producing propylene from ethane comprising the steps of:

- a. steam cracking an ethane or primarily ethane feedstock thereby producing a cracking product containing ethylene, hydrogen, ethane, methane, acetylene and C₃ and heavier hydrocarbons;
- b. treating said cracking product in an ethylene plant recovery section including removing said hydrogen, methane and C₃ and heavier hydrocarbons therefrom and converting said acetylene therein primarily to ethylene to thereby produce a treated cracking product containing primarily ethylene and ethane and including fractionating said treated cracking product in a C₂ fractionator and obtaining an ethylene fraction of chemical grade ethylene having an ethylene content of less than 99% by volume and a bottoms ethane fraction;
- c. recycling said bottoms ethane fraction to said steam cracking;
- d. reacting by dimerization in a dimerization section a first portion of said ethylene fraction thereby producing a butene-rich stream;
- e. reacting by metathesis in a metathesis section the butene in said butene-rich stream with a second portion of said ethylene fraction thereby producing a propylene-rich stream containing propylene, ethylene and ethane; and
- f. ~~producing~~ separating propylene from said ethylene and ethane in said propylene-rich stream, and

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g. recycling at least a portion of said ethylene and ethane from said propylene-rich stream to said C₂ fractionator.

Claim 2 (currently amended): A method as recited in claim 1 wherein ~~said propylene-rich stream produced in said metathesis section contains ethylene and ethane and wherein separation of said propylene from said ethylene and ethane in said propylene-rich stream takes place are removed from said propylene-rich stream~~ in a metathesis section deethanizer.

Claim 3 (currently amended): A method as recited in claim 2 wherein a second portion of said ethylene and ethane separated from propylene in said metathesis section deethanizer is condensed and returned to said metathesis section deethanizer as reflux.

Claim 4 (canceled)

Claim 5 (canceled)

Claim 6 (currently amended): A method as recited in claim 12 wherein said butene-rich stream produced in said dimerization section contains ethylene and ethane and wherein said ethylene and ethane are removed from said butene-rich stream in a dimerization section deethanizer.

Claim 7 (original): A method as recited in claim 6 wherein a first portion of said ethylene and ethane removed from said butene-rich stream is recycled to said dimerization section and a second portion is purged and recycled to said ethylene plant recovery section.

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Claim 8 (currently amended): A method as recited in claim 7 wherein said second portion of said ethylene and ethane removed from said butene-rich stream is recycled to said C₂ fractionator.

Claim 9 (original): A method as recited in claim 6 wherein said deethanized butene-rich stream contains heavier hydrocarbons and wherein said heavier hydrocarbons are separated from said butene in a butene separator.

Claim 10 (canceled)

Claim 11 (currently amended): A method as recited in claim ~~240~~ wherein all of said ethylene and ethane removed from said propylene-rich stream in said metathesis section deethanizer is are recycled directly to said C₂ fractionator.

Claim 12 (currently amended): A method as recited in claim 11 wherein a third portion of said ethylene fraction from said C₂ fractionator is fed to said metathesis section deethanizer as reflux.

Claim 13 (original): A method as recited in claim 11 wherein said butene-rich stream in said dimerization section contains heavier hydrocarbons and ethylene and ethane and wherein said heavier hydrocarbons are separated in a butene separator from said butene-rich stream and the remaining butene-rich stream containing said ethylene and ethane together with said butene is fed to said metathesis section.

Claim 14 (currently amended): A method as recited in claim 13 wherein the deethanized propylene-rich stream from metathesis contains butene and other C₄ and heavier hydrocarbons and wherein said butene and other C₄ and heavier hydrocarbons are separated therefrom and fed to said butene separator in said dimerization section.

Claim 15 (canceled)

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Claim 16 (currently amended): A method as recited in claim ~~46~~ 45 wherein a second portion of said ethylene and ethane separated from said propylene-rich stream in said metathesis section deethanizer is condensed and returned to said metathesis section deethanizer as reflux.

Claim 17 (cancelled)

Claim 18 (canceled)

Claim 19 (currently amended): A method as recited in claim ~~46~~ 48 wherein a third portion of said chemical grade ethylene fraction from said C₂ fractionator is fed to said metathesis section deethanizer as reflux.

Claim 20 (currently amended): A method as recited in claim ~~46~~ 48 wherein said butene-rich stream produced in said dimerization section contains heavier hydrocarbons and ethylene and ethane and wherein said heavier hydrocarbons are separated in a butene separator from said butene-rich stream and the remaining butene-rich stream containing said ethylene and ethane together with said butene are fed to said metathesis section.

Claim 21 (currently amended): A method as recited in claim 20 wherein the deethanized propylene-rich stream contains butene and other C₄ and heavier hydrocarbons and wherein said butene and other C₄ and heavier hydrocarbons are separated therefrom and fed to said butene separator in said dimerization section.

Claim 22 (canceled)

Claim 23 (canceled)

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Claim 24 (currently amended): A method as recited in claim 46 ~~23~~ wherein a second portion of said ethylene and ethane separated from said propylene in said metathesis section deethanizer is condensed and returned to said metathesis section deethanizer as reflux.

Claim 25 (currently amended): A method as recited in claim 46 ~~23~~ wherein all of said ethylene and ethane removed from said propylene-rich stream in said metathesis section deethanizer is are recycled to said C₂ fractionator.

Claim 26 (currently amended): A method as recited in claim 25 wherein a third portion of said chemical grade ethylene fraction from said C₂ fractionator is fed to said metathesis section deethanizer as reflux.

Claim 27 (original): A method as recited in claim 25 wherein said butene-rich stream produced in said dimerization section contains heavier hydrocarbons and ethylene and ethane and wherein said heavier hydrocarbons are separated in a butene separator from said butene-rich stream and the remaining butene-rich stream containing said ethylene and ethane together with said butene are fed to said metathesis section.

Claim 28 (original): A method as recited in claim 27 wherein the deethanized propylene-rich stream contains butene and other C₄ and heavier hydrocarbons and wherein said butene and other C₄ and heavier hydrocarbons are separated therefrom and fed to said butene separator in said dimerization section.

Claim 29 (original): A method as recited in claim 1 wherein said ethane or primarily ethane feedstock comprises a mixed ethane/propane feedstock containing at least 70% ethane.

Claim 30 (currently amended): A method of producing propylene from a hydrocarbon feedstock comprising the steps of:

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- a. steam cracking said hydrocarbon feedstock thereby producing a cracking product containing ethylene, hydrogen, ethane, methane, acetylene and C₃ and heavier hydrocarbons;
- b. treating said cracking product in an ethylene plant recovery section including removing said hydrogen, methane and C₃ and heavier hydrocarbons therefrom and converting said acetylene therein to ethylene to thereby produce a treated cracking product containing primarily ethylene and ethane and including fractionating said treated cracking product in a C₂ fractionator and obtaining a chemical grade ethylene fraction having an ethylene content less than 99% by volume and a bottoms ethane fraction;
- c. recycling said bottoms ethane fraction to said steam cracking;
- d. reacting said chemical grade ethylene fraction by metathesis in a metathesis section with butene thereby producing a propylene-rich stream containing propylene, ethylene and ethane;
- e. removing said ethylene and ethane from propylene in said propylene-rich stream in a metathesis section deethanizer; and
- f. recycling at least a portion of said removed ethylene and ethane to said C₂ fractionator ~~ethylene plant recovery section.~~

Claim 31 (currently amended): A method as recited in claim 30 wherein all of said removed ethylene and ethane is are recycled directly to said C₂ fractionator.

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Claim 32 (currently amended): A method as recited in claim 30 wherein a second portion of said removed ethylene and ethane from said metathesis section deethanizer is condensed and returned to said metathesis section deethanizer as reflux.

Claim 33 (currently amended): A method as recited in claim 30 wherein a third portion of said chemical grade ethylene fraction from said C₂ fractionator is fed to said metathesis section deethanizer as reflux.

Claim 34 (currently amended): A method as recited in ~~per~~ claim 30 where additional propylene product is obtained from ~~the~~ unsaturated C₃'s produced in the steam cracker.

Claim 35 (original): A method as recited in claim 30 wherein an additional ethylene fraction is obtained in said step of fractionating said treated cracking product and wherein said additional ethylene fraction is a polymer grade ethylene product having an ethylene content greater than 99% by volume.

Claim 36 (canceled)

Claim 37 (currently amended): A method as recited in claim 35 36 wherein a second portion of said removed ethylene and ethane from said metathesis section deethanizer is condensed and returned to said metathesis section deethanizer as reflux.

Claim 38 (currently amended): A method as recited in claim 35 36 wherein all of said ethylene and ethane removed from said propylene-rich stream in said metathesis section deethanizer is ~~are~~ recycled directly to said C₂ fractionator.

Claim 39 (currently amended): A method as recited in claim 35 38 wherein a second portion of said chemical grade ethylene fraction from said C₂ fractionator is fed to said metathesis section deethanizer as reflux.

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Claim 40 (original): A method as recited in claim 30 wherein said butene for reaction in said metathesis section comprises butene recovered from said heavier hydrocarbons in said cracking product.

Claim 41 (original): A method as recited in claim 30 wherein said butene for reaction in said metathesis section comprises butene from a source selected from refinery processes and the catalytic dehydrogenation of butanes.

Claim 42 (new): A method as recited in claim 1 wherein said ethylene fraction has an ethylene content of 90-95 %.

Claim 43 (new): A method as recited in claim 30 wherein said ethylene fraction has an ethylene content of 90-95%.

Claim 44 (new): A method as recited in claim 14 wherein said ethane or primarily ethane feedstock comprises a mixed ethane/propane feedstock containing at least 70% ethane.

Claim 45 (new): A method of producing propylene from ethane comprising the steps of:

- a. steam cracking an ethane or primarily ethane feedstock thereby producing a cracking product containing ethylene, hydrogen, ethane, methane, acetylene and C₃ and heavier hydrocarbons;
- b. treating said cracking product in an ethylene plant recovery section including removing said hydrogen, methane and C₃ and heavier hydrocarbons therefrom and converting said acetylene therein primarily to ethylene to thereby produce a treated cracking product containing primarily ethylene and ethane and including fractionating said treated cracking product in a C₂ fractionator and obtaining a chemical grade

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ethylene fraction having an ethylene content of less than 99% by volume, a polymer grade ethylene fraction having an ethylene content of at least 99.5% by volume, and a bottoms ethane fraction;

- c. recycling said bottoms ethane fraction to said steam cracking;
- d. reacting by dimerization in a dimerization section a first portion of said chemical grade ethylene fraction thereby producing a butene-rich stream;
- e. reacting by metathesis in a metathesis section the butene in said butene-rich stream with a second portion of said chemical grade ethylene fraction thereby producing a propylene-rich stream containing propylene, ethylene and ethane;
- f. separating propylene from said ethylene and ethane in said propylene-rich stream, and
- g. recycling at least a portion of said ethylene and ethane from said propylene-rich stream to said C₂ fractionator.

Claim 46 (new): A method as recited in claim 45 wherein separation of said propylene from said ethylene and ethane in said propylene-rich stream takes in a metathesis section deethanizer.

Claim 47 (new): A method as recited in claim 46 wherein a second portion of said ethylene and ethane separated from propylene in said metathesis section deethanizer is condensed and returned to said metathesis section deethanizer as reflux.

Claim 48 (new): A method as recited in claim 45 wherein said ethane or primarily ethane feedstock comprises a mixed ethane/propane feedstock containing at least 70% ethane.